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Indian Standard

QUARTZ CRYSTAL UNITS — A SPECIFICATION IN THE IEC QUALITY ASSESSMENT SYSTEM FOR ELECTRONIC COMPONENTS (IECQ) — GENERIC SPECIFICATION

ICS 31.140

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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NATIONAL FOREWORD

This Indian Standard, which is identical with IEC Pub 1178-1/QC 680000 (1993) 'Quartz crystal units — A specification in the IEC quality assessment system for electronic components (IECQ) — Part 1 : Generic specification', issued by the International Electrotechnical Commission (IEC), was adopted by the Bureau of Indian Standards on the recommendation of Piezoelectric Devices for Frequency Control and Selection Sectional Committee, LTD 12 and approval of the Electronics and Telecommunication Division Council.

The text of the IEC standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their place are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 50 International electrotechnical vocabulary (IEV)	IS 1885 Series of standards on electrotechnical vocabulary	Technically equivalent
IEC 122-3 (1977) Quartz crystal units for frequency control and selection — Part 3 : Standard outlines and lead connections	IS 4570 (Part 2 to Part 12) Series of standard on crystal unit holders	Technically equivalent
IEC 410 (1973) Sampling plans and procedures for inspection by attributes	IS 10673 : 1983 Sampling plans and procedures for inspection by attributes for electronic items	Technically equivalent
IEC 617 Graphical symbols for diagrams	IS 12032 (Part 1 to Part 13) Graphical symbols for diagrams in the field of electro-technology	Identical
IEC 1178-2 (1993) Quartz crystal units — A specification in the IEC quality assessment system for electronic components (IECQ) — Part 2 : Sectional specification — Capability approval	IS QC 680100 : 1995 Quartz crystal units — A specification in the IEC quality assessment system for electronics (IECQ) — Sectional specification — Capability approval	Identical
IEC QC 001001 (1986) Basic rules of the IEC quality assessment system for electronic components (IECQ)	IS QC 001001(1988) Basic rules of the IEC quality assessment system for electronic components (IECQ)	Identical
IEC QC 001002 (1986) Rules of procedure of the IEC quality assessment system for electronic components (IECQ)	IS QC 001002 : 1988 Rules of procedure of the IEC quality assessment system for electronic components (IECQ)	Identical
ISO 1000 (1981) SI units and recommendations for the use of their multiples and of certain other units	IS 10005 : 1985 SI units and recommendations for the use of their multiples and of certain other units	Identical

(Continued on third cover)

Indian Standard

QUARTZ CRYSTAL UNITS — A SPECIFICATION IN THE IEC QUALITY ASSESSMENT SYSTEM FOR ELECTRONIC COMPONENTS (IECQ) — GENERIC SPECIFICATION

1 General

1.1 *Scope*

This part of IEC 1178 specifies the methods of test and general requirements for quartz crystal units of assessed quality using either capability approval or qualification approval procedures according to clause 11 of IECQ 001002.

1.2 *Normative references*

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 1178. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 1178 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 27, *Letter symbols to be used in electrical technology*

IEC 50, *International Electrotechnical Vocabulary (IEV)*

IEC 68-1: 1988, *Environmental testing – Part 1: General and guidance*

IEC 68-2-1: 1990, *Environmental testing – Part 2: Tests – Tests A: Cold*

IEC 68-2-2: 1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*
Supplement A: 1976

IEC 68-2-3: 1969, *Environmental testing – Part 2: Tests – Test Ca: Damp heat, steady state*
Amendment 1: 1984

IEC 68-2-6: 1982, *Environmental testing – Part 2: Tests – Test Fc and guidance: Vibration (sinusoidal)*
Amendment 1: 1983
Amendment 2: 1985

IEC 68-2-7: 1983, *Environmental testing – Part 2: Tests – Test Ga and guidance: Acceleration, steady state*
Amendment 1: 1986

IEC 68-2-14: 1984, *Environmental testing - Part 2: Tests – Test N: Change of temperature*

Amendment 1: 1986

IEC 68-2-17: 1978, *Environmental testing – Part 2: Tests – Test Q: Sealing*

Amendment 4: 1991

IEC 68-2-20: 1979, *Environmental testing – Part 2: Tests – Test T: Soldering*
Amendment 2: 1987

IEC 68-2-21: 1983, *Environmental testing – Part 2: Tests – Test U: Robustness of terminations and integral mounting devices*
Amendment 1: 1985

IEC 68-2-27: 1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

IEC 68-2-29: 1987, *Environmental testing – Part 2: Tests – Test Eb and guidance: Bump*

IEC 68-2-30: 1980, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12+12-hour cycle)*
Amendment 1: 1985

IEC 68-2-32: 1975, *Environmental testing – Part 2: Tests – Test Ed: Free fall*

Amendment 2: 1990

IEC 68-2-45: 1980, *Environmental testing – Part 2: Tests – Test XA and guidance: Immersion in cleaning solvents*

IEC 122-1: 1976, *Quartz crystal units for frequency control and selection – Part 1: Standard values and test conditions*
Amendment 1: 1983

IEC 122-3: 1977, *Quartz crystal units for frequency control and selection – Part 3: Standard outlines and lead connections*
Amendment 2: 1991
Amendment 3: 1992
Amendment 4: 1993

IEC 302: 1969, *Standard definitions and methods of measurement for piezoelectric vibrators operating over the frequency range up to 30 MHz*

IEC 410: 1973, *Sampling plans and procedures for inspection by attributes*

IEC 444-1: 1984, *Measurement of quartz crystal unit parameters by zero phase technique in a π-network – Part 1: Basic method for the measurement of resonance frequency and resonance resistance of quartz crystal units by zero phase technique in a π-network*

IEC 444-2: 1980, *Measurement of quartz crystal unit parameters by zero phase technique in a π-network – Part 2: Phase offset method for measurement of motional capacitance of quartz crystal units*

IEC 444-3: 1986, *Measurement of quartz crystal unit parameters by zero phase technique in a π-network – Part 3: Basic method for the measurement of two-terminal parameters of quartz crystal units up to 200 MHz by phase technique in a π-network with compensation of the parallel capacitance* C_o

IEC 444-4: 1988, *Measurement of quartz crystal unit parameters by zero phase technique in a π-network – Part 4: Method for the measurement of the load resonance frequency* f_L, *load resonance resistance* R_L *and the calculation of other derived values of quartz crystal units, up to 30 MHz*

IEC 617, *Graphical symbols for diagrams*

IEC 1178-2: 1993, *Quartz crystal units – A specification in the IEC Quality Assessment System for Electronic Components (IECQ) – Part 2: Sectional specification – Capability approval*

IEC 1178-3: 1993: *Quartz crystal units – A specification in the IEC Quality Assessment System for Electronic Components (IECQ) – Part 3: Sectional specification – Qualification approval*

IEC QC 001001: 1986, *Basic rules of the IEC Quality Assessment System for Electronic Components (IECQ)*

IEC QC 001002: 1986, *Rules of Procedure of the IEC Quality Assessment System for Electronic Components (IECQ)*

IEC QC 001005: 1992, *Qualified Products List*

IEC Guide 102: 1989, *Electronic components. Specification structures for quality assessment (Qualification approval and capability approval)*

ISO 1000: 1981, *SI units and recommendations for the use of their multiples and of certain other units*

2 Technical

2.1 *Order of precedence*

Where any discrepancies occur for any reason, documents shall rank in the following order of precedence:

- the detail specification;
- the sectional specification;
- the generic specification;
- any other international documents (for example of the IEC) to which reference is made.

The same order of precedence shall apply to equivalent national documents.

2.2 *Units, symbols and terminology*

2.2.1 *General*

Units, graphical symbols, letter symbols and terminology shall, wherever possible, be taken from the following Standards:

- IEC 27;
- IEC 50;
- IEC 617;
- ISO 1000.

The following paragraphs contain additional terminology applicable to quartz crystal units.

2.2.2 *Crystal element (crystal blank)*

Piezoelectric material cut to a given geometrical shape, size and orientation with respect to the crystallographic axes of the crystal.

2.2.3 *Electrode*

An electrically conductive plate or film in contact with, or in proximity to, a face of a crystal element by means of which an electric field is applied to the element.

2.2.4 *Crystal resonator*

A mounted crystal element that vibrates when an alternating electric field exists between the electrodes.

2.2.5 *Mounting*

The means by which the crystal resonator is supported (within its enclosure).

2.2.6 *Enclosure*

The enclosure protecting the crystal resonator(s) and mounting.

2.2.7 *Enclosure type*

A crystal enclosure of specific outline dimensions and material with a defined method of sealing.

2.2.8 *Crystal unit*

A crystal resonator mounted in an enclosure.

2.2.9 *Socket*

A component into which the crystal unit is inserted to hold the crystal unit and to provide electrical connection.

2.2.10 *Mode of vibration*

The pattern of motion in a vibrating body of the individual particles resulting from stresses applied to the body, the frequency of oscillation and the boundary conditions existing. The common modes of vibration are:

- flexural;
- extensional;
- face shear;
- thickness shear.

2.2.11 *Fundamental crystal unit*

A crystal resonator designed to operate at the lowest order of a given mode.

2.2.12 *Overtone crystal unit*

A crystal resonator designed to operate at a higher order than the lowest of the given mode.

2.2.13 *Overtone order*

The numbers allotted to the successive overtones of a given mode of vibration from the ascending series of integral numbers commencing with the fundamental as unity. For shear and extensional modes, this overtone is the integral multiple of the fundamental frequency to which the overtone frequency approximates.

2.2.14 *Crystal unit equivalent circuit*

The electric circuit which has the same impedance as the crystal unit in the region of the desired resonance and anti-resonance frequencies. It is represented by an inductance, capacitance and resistance in series, this series arm being shunted by the capacitance between the terminals of the unit. The parameters of the series branch of inductance, capacitance and resistance are given by L_1, C_1 and R_1 respectively; these are termed "motional parameters" of the crystal unit. The shunt (parallel) capacitance is denoted by C_0 (see figure 1).

NOTES

1 The equivalent circuit does not represent all the characteristics of a crystal unit.

2 The values of R_e, X_e, G_p and B_p vary rapidly around the resonance frequency, where:

R_e is the equivalent circuit series resistance of the resonator;

X_e is the equivalent circuit series reactance of the resonator;

G_p is the equivalent circuit parallel conductance of the resonator;

B_p is the equivalent circuit parallel susceptance of the resonator.

2.2.15 *Motional resistance* (R_1)

The resistance in the motional (series) arm of the equivalent circuit.

2.2.16 *Motional inductance* (L_1)

The inductance in the motional (series) arm of the equivalent circuit.

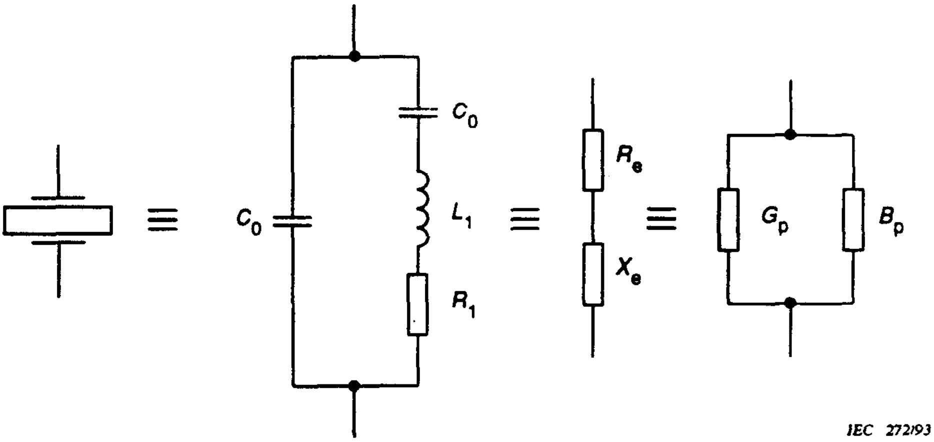


Figure 1 – Symbol and equivalent electrical circuit of a piezoelectric resonator near a resonance

2.2.17 *Motional capacitance* (C_1)

The capacitance in the motional (series) arm of the equivalent circuit.

2.2.18 *Shunt capacitance* (C_0)

The shunt capacitance in parallel with the motional arm of the equivalent circuit.

2.2.19 *Resonance frequency* (f_r)

The lower of the two frequencies of the crystal unit alone, under specified conditions, at which the electrical impedance of the crystal unit is resistive.

2.2.20 *Resonance resistance* (R_r)

The resistance of the crystal unit alone at the resonance frequency f_r.

2.2.21 *Anti-resonance frequency* (f_a)

The higher of the two frequencies of the crystal unit alone, under specified conditions, at which the electrical impedance of the crystal unit is resistive.

2.2.22 *Load capacitance* (C_L)

The effective external capacitance associated with the crystal unit which determines the load resonance frequency f_L.

2.2.23 *Load resonance frequency* (f_L)

One of the two frequencies of a crystal unit in association with a series or with a parallel load capacitance, under specified conditions at which the electrical impedance of the combination is resistive. The load resonance frequency is the lower of the two frequencies when the load capacitance is in series and the higher when it is in parallel (see figure 2).

For a given value of load capacitance C_L, these frequencies are identical for all practical purposes and are given by the expression

$$\frac{1}{f} = 2\pi \sqrt{\left[\frac{L_1 C_1 (C_o + C_L)}{C_1 + C_o + C_L}\right]}$$

NOTES

1 The frequencies defined in 2.2.19, 2.2.21 and 2.2.23 are listed as being the terms more commonly used. The frequencies associated with a quartz crystal are numerous and for a full explanation IEC 302 should be consulted.

2 When higher accuracies are required or secondary data (for example, values of crystal unit motional parameters) are to be derived from the frequency measurements, IEC 302 and IEC 444-1 should be consulted.

2.2.24 *Load resonance resistance* (R_L)

The resistance of the crystal unit in series with a stated external capacitance at the load resonance frequency f_L.

NOTE - To a close approximation the value of R_L is related to the value of R_r by the expression:

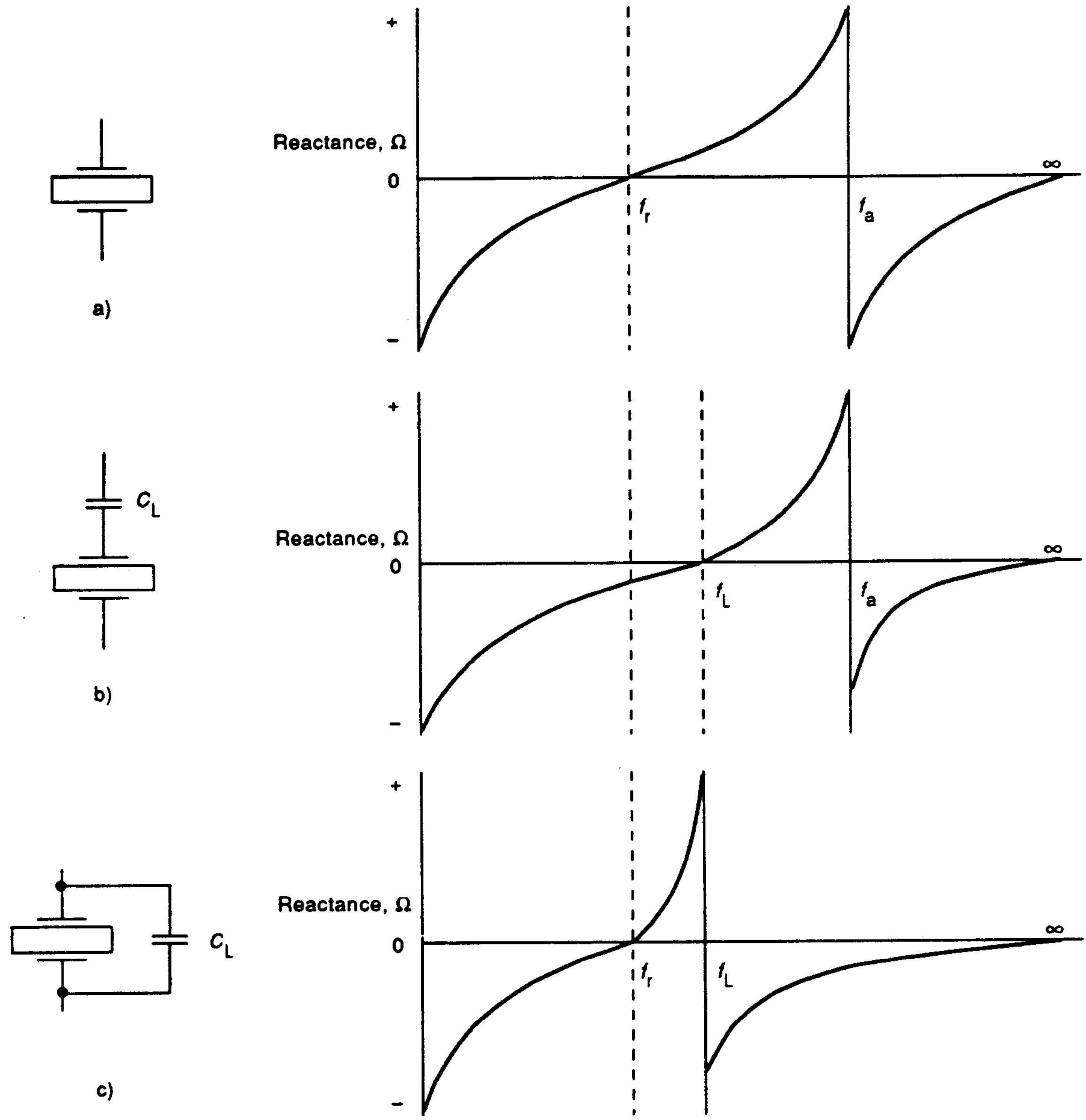
$$R_L \cong R_r \left(1 + \frac{C_o}{C_L}\right)^2$$

2.2.25 *Nominal frequency* (f_n)

The frequency assigned to the crystal unit by the manufacturer.

2.2.26 *Working frequency* (f_w)

The operational frequency of the crystal unit together with associated circuits.



IEC 273/93

NOTES

1 The values of load capacitances shown in b) and c) are equal.

2 See 2.2.19, 2.2.21 and 2.2.23.

Figure 2 – Resonance, anti-resonance and load resonance frequencies

2.2.27 *Load resonance frequency offset* (Δf_L)

$$\Delta f_L = f_L - f_r$$

It can be calculated approximately from

$$\Delta f_L \cong \frac{f_r C_1}{2\,(C_o + C_L)}$$

In usage, the load resonance frequency offset Δf_L for a given value of load capacitance can be written as, for instance, Δf_{30} or Δf_{20} to indicate the actual value of load capacitance in picofarads involved.

2.2.28 Fractional load resonance frequency offset (D_L)

$$D_L = \frac{f_L - f_r}{f_r}$$

It can be calculated approximately from

$$D_L \cong \frac{C_1}{2\,(C_o + C_L)}$$

This can also be written as, for instance, D_{30} to indicate the fractional load resonance frequency offset D_L with a load capacitance of 30 pF.

2.2.29 *Frequency pulling range ($\Delta f_{L1,\,L2}$)*

$$\Delta f_{L1,\,L2} = |\, f_{L1} - f_{L2} \,|$$

It can be calculated approximately from:

$$\Delta f_{L1,\,L2} = \left| \frac{f_r C_1 \,(C_{L2} - C_{L1})}{2\,(C_o + C_{L1})\,(C_o + C_{L2})} \right|$$

This can also be written as, for instance $\Delta f_{20,\,30}$ to indicate the fractional pulling range between load capacitance of 20 pF and 30 pF.

2.2.30 Fractional pulling range ($D_{L1,\,L2}$)

$$D_{L1,\,L2} = \left| \frac{f_{L1} - f_{L2}}{f_r} \right| = \left| D_{L1} - D_{L2} \right|$$

It can be calculated approximately from:

$$D_{L1,\,L2} = \left| \frac{C_1\,(C_{L2} - C_{L1})}{2\,(C_o + C_{L1})\,(C_o + C_{L2})} \right|$$

This can be written as, for instance, $D_{20,\,30}$, to indicate the frequency pulling range between load capacitances of 20 pF and 30 pF.

2.2.31 Pulling sensitivity (S)

$$S = \frac{d D_L}{d C_L} \cong \frac{-C_1}{2 (C_o + C_L)^2}$$

This can be written as, for instance, S_{30}, to indicate the pulling sensitivity at a load capacitance of 30 pF.

2.2.32 *Operating temperature range*

The range of temperatures as measured on the enclosure, over which the crystal unit shall be within the specified tolerances.

2.2.33 *Operable temperature range*

The range of temperatures as measured on the enclosure over which the crystal unit will not sustain permanent damage though not necessarily functioning within the specified tolerances.

2.2.34 *Storage temperature range*

The minimum and maximum temperatures, as measured on the enclosure, at which the crystal unit may be stored without deterioration or damage to its performance.

2.2.35 *Reference temperature*

The temperature at which certain crystal measurements are made. For controlled temperature units the reference temperature is the mid-point of the controlled temperature range. For non-controlled temperature units the reference temperature is normally 25 °C ± 2 °C.

2.2.36 *Level of drive*

A measure of the conditions imposed upon the crystal unit. This may be expressed in terms of current through or power dissipated in the crystal element.

2.2.37 *Drive level dependency*

Drive level dependency (DLD) is the effect of changes in drive level conditions upon the resonance resistance of the crystal unit. This parameter can be specified by defining the ratio of resistance between two specified drive levels. This ratio is represented by the expression:

$$\frac{R_{r1}}{R_{r2}}$$

where

R_{r1} is the resistance at the lower level of drive

R_{r2} is the resistance at the higher level of drive

2.2.38 *Unwanted response*

A state of resonance of a crystal resonator other than that associated with the working frequency.

2.2.39 *Frequency tolerance*

The maximum permissible deviation of the working frequency due to a specified cause or a combination of causes. The frequency tolerance is usually stated in parts per million (1 x 10^{-6}) of the nominal frequency.

NOTE – The tolerances normally used are as follows:

- deviation from nominal frequency at the reference temperature under specified conditions;
- deviation over the temperature range from the frequency at the specified reference temperature;
- deviation as a result of ageing under specified conditions;
- deviation from nominal frequency due to all causes (overall tolerance).

2.3 *Preferred ratings and characteristics*

Values should preferably be chosen from the following paragraphs:

2.3.1 *Temperature ranges in degrees Celsius (°C) suitable for ambient operation*

–55 to +125
–55 to +105
–55 to +100
–55 to +90
–40 to +90
–40 to +85
–40 to +80
–40 to +70
–30 to +80
–30 to +70
–25 to +80
–20 to +85
–20 to +80
–20 to +70
–20 to +60
–10 to +70
–10 to +60
–10 to +50
0 to +60
0 to +50
+5 to +55
+10 to +40
+15 to +50

2.3.2 *Elevated temperature ranges in degrees Celsius (°C) suitable for oven control*

60 ± 5
65 ± 5
70 ± 5
75 ± 5
80 ± 5
85 ± 5

2.3.3 *Frequency tolerance (1 x 10^{-6})*

±200
±100
±50
±40
±30
±25
±20
±15
±10
±7,5
±5
±4
±2,5
±1

2.3.4 *Circuit conditions*

10 pF load capacitance

15 pF load capacitance

20 pF load capacitance

30 pF load capacitance
50 pF load capacitance
Series resonance.

2.3.5 *Levels of drive*

- Thickness shear/AT:
  Current, in µA
  150
  200
  1 000
  2 000
  Power, in µW
  1
  10
  100
  500
- Flexure and face shear:
  Current, in µA
  100
  200
- Extensional:
  Current, in µA
  500
  1 000

2.3.6 *Drive level dependency*

Resonance resistance Ω	Resistance ratio $\frac{R_{r1}}{R_{r2}}$
<5	2,2
5 to 10	2,0
10 to 20	1,8
20 to 35	1,5
35 to 50	1,3
>50	1,2

2.3.7 *Climatic category*

55/105/56

For requirements where the operating temperature range of the crystal unit is greater than −55 °C to +105 °C, a climatic category consistent with the operating temperature range shall be specified.

2.3.8 *Bump severity*

4 000 ± 10 bumps at 390 m/s^2 peak acceleration in each direction along three mutually perpendicular axes (see 4.8.6).

Pulse duration 6 ms.

2.3.9 *Vibration severity*

10 Hz to 55 Hz 0,75 mm displacement amplitude (peak value) 55 Hz to 500 Hz or 55 Hz to 2 000 Hz 98,1 m/s^2 acceleration amplitude (peak value)	30 min in each of three mutually perpendicular axes at 1 octave/min (see 4.8.7)
10 Hz to 55 Hz 1,5 mm displacement amplitude (peak value) 55 Hz to 2 000 Hz 196,2 m/s^2 acceleration amplitude (peak value)	30 min in each of three mutually perpendicular axes at 1 octave/min (see 4.8.7)

Random vibration severities: under consideration.

2.3.10 *Shock severity*

981 m/s^2 peak acceleration for 6 ms duration; three shocks in each direction along three mutually perpendicular axes (see 4.8.8), half sine pulse, unless otherwise stated in the detail specification.

2.3.11 *Leak rate*

10^{-3} Pa cm^3/s (10^{-8} mbar l/s).

2.4 *Marking*

2.4.1 The information given in the marking is selected from the following list; the relative importance of each item is indicated by its position in the list:

1) type designation as defined in the detail specification;
2) nominal frequency in kHz or MHz;

3) year and week (four digits) of manufacture;
4) factory identification code;
5) manufacturer's name or trade mark;
6) mark of conformity (unless a certificate of conformity is used).

2.4.2 The crystal units shall be clearly marked with 1), 2) and 3) above and with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the crystal unit should be avoided.

Where the available surface area of miniature crystal enclosures imposes practical limits on the amount of marking, instructions on the marking to be applied shall be given in the detail specification.

2.4.3 The primary package containing the crystal unit(s) shall be clearly marked with all the information listed in 2.4.1.

2.4.4 Any additional marking shall be so applied that no confusion can arise.

3 Quality assessment procedures

Two methods are available for the approval of quartz crystal units of assessed quality. They are qualification approval and capability approval.

3.1 *Primary stage of manufacture*

In accordance with 11.1.1 of IEC QC 001002, the primary stage of manufacture is the final surface finishing of the crystal element.

NOTE - The final surface finishing of the crystal element could be any of the following operations: lapping; polishing; etching; cleaning, in the case of polished plates.

3.2 *Structurally similar components*

The grouping of structurally similar components for the purpose of qualification approval, capability approval and quality conformance inspection shall be prescribed in the relevant sectional specification.

3.3 *Subcontracting*

These procedures shall be in accordance with 11.1.2 of IEC QC 001002.

However, the final surface finishing of the crystal elements and all subsequent processes shall be carried out by the manufacturer to whom approval has been granted.

3.4 *Manufacturer's approval*

To obtain manufacturer's approval the manufacturer shall meet the requirements of 10.2 of IEC QC 001002.

3.5 *Approval procedures*

3.5.1 *General*

To qualify a quartz crystal unit, either capability approval or qualification approval procedures may be used. These procedures conform to those stated in IEC QC 001001 and IEC QC 001002.

3.5.2 *Capability approval*

Capability approval is appropriate when structurally similar quartz crystal units based on common design rules, are fabricated, by a group of common processes.

Under capability approval detail specifications fall into the following three categories.

1) Capability qualifying components (CQCs)

A detail specification shall be prepared for each CQC as agreed with the NSI. It shall identify the purpose of the CQC and include all relevant stress levels and test limits.

2) Standard catalogue items

When a component covered by the capability approval procedure is intended to be offered as a standard catalogue item, a detail specification complying with the blank detail specification shall be written. Such specifications shall be registered by the IECQ and the component may be listed in IEC QC 001005: Qualified products list.

3) Custom built quartz crystal units

The content of the detail specification shall be determined by agreement between the manufacturer and the customer in accordance with 11.7.4.2 of IEC QC 001002.

Further information on detail specifications is contained in the sectional specification IEC 1178-2.

The product and capability qualifying components (CQCs) are tested in combination and approval given to a manufacturing facility on the basis of validated design rules, processes and quality control procedures. Further information is given in 3.6 and in the sectional specification IEC 1178-2.

3.5.3 *Qualification approval*

Qualification approval is appropriate for components manufactured to a standard design and established production process and conforming to a published detail specification.

The programme of tests defined in the detail specification for the appropriate assessment and severity level applies directly to the quartz crystal unit to be qualified, as prescribed in 3.7 and the sectional specification IEC 1178-3.

3.6 *Procedures for capability approval*

3.6.1 *General*

The procedures for capability approval shall be in accordance with IEC QC 001002.

3.6.2 *Eligibility for capability approval*

The manufacturer shall comply with the requirements of 11.1 of IEC QC 001002 and the primary stage of manufacture as defined in 3.1 of this generic specification.

3.6.3 *Application for capability approval*

In order to obtain capability approval the manufacturer shall apply the rules of procedure given in 11.7 of IEC QC 001002.

3.6.4 *Granting of capability approval*

Capability approval shall be granted when the procedures in accordance with 11.7 of IEC QC 001002 have been successfully completed.

3.6.5 *Capability manual*

The contents of the capability manual shall be in accordance with the requirements of the sectional specification. The NSI shall treat the capability manual as a confidential document. The manufacturer may, if he so wishes, disclose part or all of it to a third party.

3.7 *Procedures for qualification approval*

3.7.1 *General*

The procedures for qualification approval shall be in accordance with IEC QC 001002.

3.7.2 *Eligibility for qualification approval*

The manufacturer shall comply with the requirements of 11.1 of IEC QC 001002 and the primary stage of manufacture as defined in 3.1 of this generic specification.

3.7.3 *Application for qualification approval*

In order to obtain qualification approval the manufacturer shall apply the procedures given in 11.2 of IEC QC 001002.

3.7.4 *Granting of qualification approval*

Qualification approval shall be granted when the procedures in accordance with 11.3 of IEC QC 001002 have been successfully completed.

3.7.5 *Quality conformance inspection*

The blank detail specification associated with the sectional specification shall prescribe the test schedule for quality conformance inspection.

3.8 *Test procedures*

The test procedures to be used shall be selected from this generic specification. If any required test is not included then it shall be defined in the detail specification.

3.9 *Screening requirements*

Where screening is required by the customer for quartz crystal units this shall be specified in the detail specification.

3.10 *Rework and repair work*

3.10.1 *Rework*

Rework is the rectification of processing errors and shall not be carried out if prohibited by the sectional specification. The sectional specification shall state if there is a restriction on the number of occasions that rework may take place on a specific component.

All rework shall be carried out prior to the formation of the inspection lot offered for inspection to the requirements of the detail specification.

Such rework procedures shall be fully described in the relevant documentation produced by the manufacturer and shall be carried out under the direct control of the chief inspector. Sub-contracting of rework is not permitted.

3.10.2 *Repair work*

Repair work is the correction of defects in a component after release to the customer.

Components that have been repaired can no longer be considered as representative of the manufacturer's production and may not be released under the IECQ System.

3.11 *Certified test records*

The requirements of clause 14 of IEC QC 001002 shall apply. When certified test records are prescribed in the sectional specification for qualification approval and are requested by the customer the results of the specified tests shall be summarized.

3.12 *Delayed delivery*

Crystal units held for a period exceeding two years following acceptance inspection shall be reinspected for the electrical tests detailed in 4.7.1 and 4.7.3, with a sample tested as described in item 1) of 4.8.3, prior to release.

3.13 *Release for delivery*

Quartz crystal units shall be released in accordance with 12.5 of IEC QC 001002.

3.14 *Unchecked parameters*

Only those parameters of a component which have been specified in a detail specification and which were subject to testing can be assumed to be within the specified limits. It should not be assumed that any parameter not specified will remain unchanged from one component to another. Should it be necessary for further parameters to be controlled, then a new, more extensive, detail specification should be used. Any additional test method(s) shall be fully described and appropriate limits, AQLs and inspection levels specified.

4 Test and measurement procedures

4.1 *General*

The test and measurement procedures shall be carried out in accordance with the relevant detail specification.

4.2 *Alternative test methods*

Measurements shall preferably be carried out using the methods specified. Any other method giving equivalent results may be used except in case of dispute.

NOTE - By "equivalent" it is meant that the value of the characteristic established by such other method falls within the specified limits when measured by the specified method.

4.3 *Precision of measurement*

The limits given in detail specifications are true values. Measurement inaccuracies shall be taken into account when evaluating the results. Precautions should be taken to reduce measurement errors to a minimum.

4.4 *Standard conditions for testing*

Unless otherwise specified, all tests shall be carried out under the standard atmospheric conditions for testing as specified in 5.3 of IEC 68-1.

Temperature	15 °C to 35 °C
Relative humidity	45 % to 75 %
Air pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)

In case of dispute, the referee conditions are:

Temperature	25 °C ± 1 °C
Relative humidity	48 % to 52 %
Air pressure	86 kPa to 106 kPa (860 mbar to 1 060 mbar)

Before measurements are made, the crystal units shall be stored at the measuring temperature for a time sufficient to allow the crystal resonator to reach this temperature.

Controlled recovery conditions and standard conditions for assisted drying are given in 5.4 of IEC 68-1.

The ambient temperature during the measurements shall be recorded and stated in the test report.

4.5 *Visual inspection*

Unless otherwise specified, external visual examination shall be performed under normal factory lighting and visual conditions.

4.5.1 *Visual Test A*

The crystal unit shall be visually examined to ensure that the condition, workmanship and finish are satisfactory. The marking shall be legible.

4.5.2 *Visual Test B*

The crystal unit shall be visually examined under x10 magnification. There shall be no cracks in the glass or damage to the terminations. Minute flacking around the feather edge of a meniscus shall not be considered a crack.

4.5.3 *Visual Test C*

The crystal unit shall be visually examined. There shall be no corrosion or other deterioration likely to impair satisfactory operation. The marking shall be legible.

4.6 *Dimensioning and gauging procedures*

4.6.1 *Dimensions, Test A*

The dimensions, spacing and alignment of the terminations shall be checked, where appropriate, using the gauges specified in IEC 122-3. The dimensions, spacing and alignment shall comply with the specified values.

4.6.2 *Dimensions, Test B*

The dimensions shall be measured and they shall comply with the specified values. Dimensions are specified in IEC 122-3 together with the gauging procedure as appropriate or as specified in the detail specification.

4.7 *Electrical test procedures*

4.7.1 *Frequency and resonance resistance*

Unless otherwise defined in the detail specification, the measurements shall be carried out at 25 °C ± 2 °C for non-temperature controlled crystal units; or at the mid-point of the temperature range ±1 °C for temperature controlled units.

The frequency and resonance resistance of the crystal unit shall be measured under the conditions stated in the detail specification and be within the specified limits.

NOTE - Preferred methods of measurement are described in IEC 444-1, IEC 444-2, IEC 444-3, IEC 444-4 and IEC 302 depending on the frequency of the crystal unit under test. Any other measurement method may be used provided the results correlate with those obtained using the preferred methods.

4.7.2 *Drive level dependency*

It is important that when a drive level dependency test is specified, this test shall be carried out at least five days after any previous activation of the crystal unit.

Measurements specified in 4.7.1 shall be carried out at two specified drive levels. These are normally at a specified low level of drive followed by a high level of drive. Unless otherwise specified, the low level shall be not more than 50 µA and the upper level not less than 1 000 µA. The change of resonance resistance shall not exceed the limit specified in the detail specification.

4.7.3 *Frequency and resonance resistance as a function of temperature*

NOTE - Tests A and B may be combined only if Test A is performed with continuously varying temperature, and is started at the lower extreme of the operating temperature range or –30 °C, whichever is the lower.

The level of drive and load capacitance shall be set at the levels stated in the detail specification, at the reference temperature. No subsequent adjustment shall be made to the test equipment during the tests.

Test A

Starting with the crystal unit at an extreme of the operating temperature range, the frequency and resonance resistance (see 4.7.1) shall be measured over the specified temperature range at discrete temperature intervals of not greater than 1,5 °C, allowing the crystal unit to reach thermal equilibrium at each temperature.

The crystal unit may be measured under conditions of continuously varying temperature, provided that tests have shown that with the chosen rate of change of temperature, the results obtained will correlate adequately with those from a stepped variation of temperature.

The crystal unit shall be within the specified limits during this test.

Test B

The temperature of the crystal enclosure shall be raised from –30 °C to +20 °C in a period not exceeding 1 min. During this test, the frequency and the resonance resistance (see 4.7.1) shall be measured from –10 °C, or below, to +20 °C, so as to provide continuous readings. There shall be no discontinuous variation in frequency and/or resistance. Such discontinuities indicate the presence of moisture within the enclosure.

NOTE - The presence of moisture can be verified only by a positive temperature change.

4.7.4 *Unwanted responses*

The frequency shall be scanned over the range stated in the detail specification while monitoring the resistance of the crystal unit at the drive level stated in the detail specification for the main response.

The ratio of the resonance resistance of any unwanted response to that of the response at the desired resonance frequency shall not be less than the value stated in the detail specification. Alternatively, the resonance resistance of unwanted responses shall be greater than the value stated in the detail specification.

4.7.5 *Shunt capacitance*

The shunt capacitance C_0 (see figure 1) shall be measured at a frequency below the fundamental resonance frequency of the unit, at which the unit shows no oscillation response. The enclosure (if metal) shall be earthed, unless otherwise stated in the detail specification.

NOTE – There is no direct method for measuring C_0 precisely. However, in nearly all practical cases it is adequate to regard C_0 as the mean of two shunt capacitance values obtained at two frequencies equidistant above and below the resonance frequency f_r and sufficiently removed from f_r for the impedance to be independent of any response.

C_0 is the shunt capacitance between the two electrodes of the resonator but is should be pointed out that the capacitances of both the electrodes to earth are important elements in many network and frequency control applications.

Therefore, in the general case, it is necessary to consider the crystal unit as a three terminal network and to evaluate C_0 and the stray capacitances of the two electrodes to earth from open and short circuit measurements according to the technique customarily employed when dealing with two-port devices.

The crystal enclosures shall be at earth potential, unless otherwise specified in the detail specification, during the entire series of measurements required for evaluation of the resonator parameters. For this purpose glass-enclosed crystal units shall be provided with metal shields.

4.7.6 *Load resonance frequency and resistance*

Test methods for the measurement of load resonance frequency and load resonance resistance are described in IEC 444-4.

4.7.7 *Frequency pulling range* ($f_{L1,\ L2}$)

The difference between the resonance frequencies with the two specified load capacitances shall be determined using the method described in IEC 444-4 or any alternative method giving frequency correlation to a degree consistent with the accuracy required.

4.7.8 *Motional parameters*

Test methods for the measurement of motional parameters are described in IEC 444-1 and IEC 444-2.

4.7.9 *Insulation resistance*

Unless otherwise stated in the detail specification, the insulation resistance shall be measured with a d.c. voltage of 100 V ± 15 V for 60 s or less if a stable reading is achieved, applied between:

- terminations isolated from the case;
- isolated terminations connected together and metal parts of the case, if any.

The insulation resistance shall not be less than 500 MΩ.

NOTE - When performing this test care should be taken to ensure that no moisture remains on the enclosure from any previous tests.

4.8 *Mechanical and environmental test procedures*

4.8.1 *Robustness of terminations (destructive)*

1) *Tensile and thrust tests on terminations*

The tests shall be performed in accordance with Test Ua_1 (tensile) and Test Ua_2 (thrust) of IEC 68-2-21.

Unless otherwise stated in the detail specification, the loading mass shall be:

– for pin (plug-in) terminations:	20 N thrust,
– for pin (plug-in) terminations:	20 N tensile,
– for wire (solder) terminations:	10 N tensile.

2) *Flexibility of wire terminations*

The test shall be performed in accordance with Test Ub (bending) of IEC 68-2-21.

Unless otherwise stated in the detail specification, the load shall be so restricted that the bend starts 2,5 mm ± 0,5 mm from the body of the crystal unit, the loading mass shall be 5 N and the number of bends shall be three.

3) *Terminal bend test (for undercut pins only)*

Hold or clamp the body or base of the crystal unit by any convenient means. Use the bending tool shown in figure 3 to engage that segment of the terminals beyond the undercut section of the pins.

NOTE - To ensure that bending will occur primarily at the undercut portion, a plate with two clearance holes for the pins may be placed over the pins. This plate may be of such a thickness as to include a portion of the undercut section of the pins.

Bend the pins by means of the tool through 15° ± 2° in one direction, follow by a bend of 30° ± 2° in the opposite direction, and complete by a bend of 15° ± 2° back to the starting position. The rate of bending shall be approximately 5° per second in each direction.

When this test is used the terminal pins shall not fracture.

4.8.2 *Sealing tests (non destructive)*

1) *Gross leak test*

This test shall be performed in accordance with the procedure specified in Test Method 1 or 2 of Test Qc of IEC 68-2-17.

Method 1

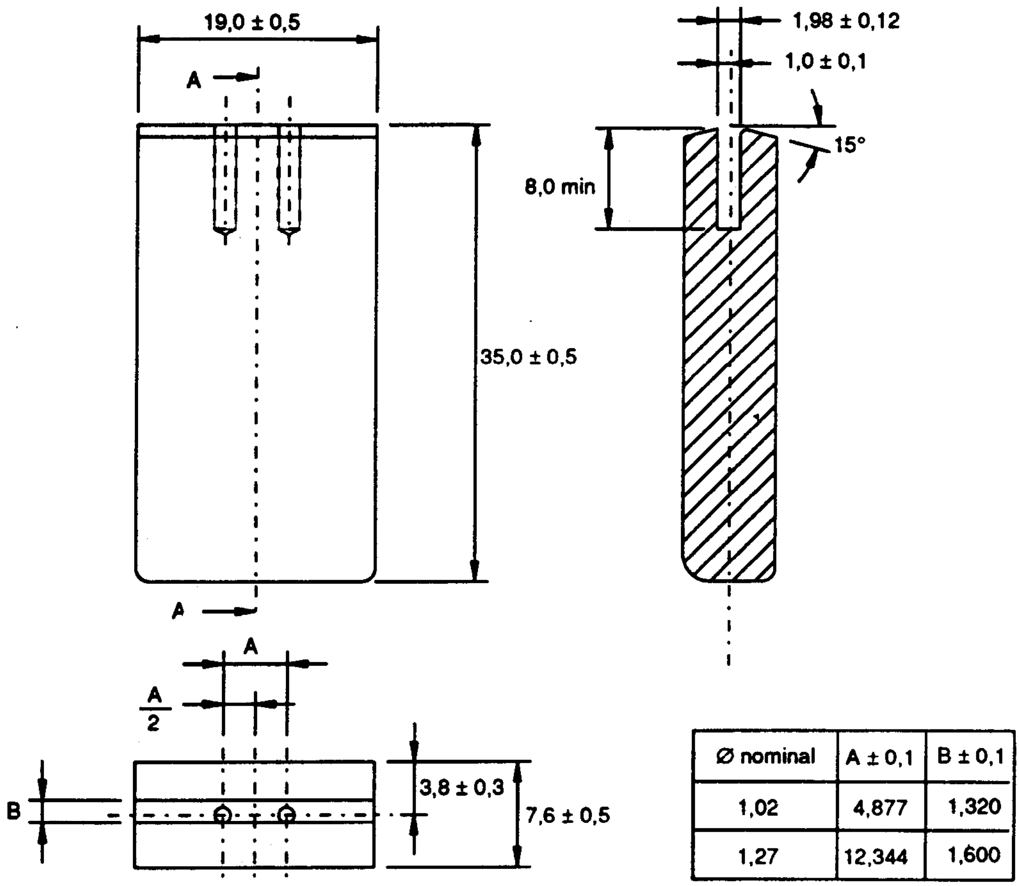
The liquid shall be degassed water and the pressure of air above the water shall be reduced to 8,5 kPa (85 mbar) or less and it shall not be necessary to drain or remove the specimen from the water before breaking the vacuum.

Method 2

The liquid shall be maintained at 125 °C ± 5 °C. The immersion time shall be 30 s, unless otherwise specified in the relevant detail specification.

After 1 min, the unit shall be removed from the chamber and exposed to the controlled recovery conditions specified in 5.4.1 of IEC 68-1.

During the test there shall be no evidence of leakage of gas or air from the inside of the crystal unit. The continuous formation of bubbles shall be evidence of leakage.



Ø nominal	A ± 0,1	B ± 0,1
1,02	4,877	1,320
1,27	12,344	1,600

All dimensions are in millimetres

Figure 3 – Terminal bend test tool

2) *Fine leak test*

The test shall be performed in accordance with 6.4 Test Method 1 of Test Qk of IEC 68-2-17. Unless otherwise stated in the detail specification, the pressure in the pressure vessel shall be 200 kPa (2 bar).

The maximum leak rate shall not exceed the value given in 2.3.11, unless otherwise stated in the detail specification.

3) *Vacuum test for evacuated crystal units (glass enclosure types only)*

The vacuum shall be checked by applying a peak voltage not exceeding 15 kV derived from a Tesla coil.

To avoid damage to the crystal unit, the point of application of the test electrode shall be as remote as possible from the crystal resonator and its terminations. To facilitate observation of the resulting discharge, the test shall be carried out in semi-darkness. There shall be no indication of arcing within the enclosure. Where a uniform discharge occurs, it shall be a pale bluish colour.

NOTE - This test should be conducted in the shortest possible time, as this test may cause changes in the nominal frequency of the crystal unit under test.

4.8.3 *Soldering (solderability and resistance to soldering heat) (destructive)*

1) *Solderability*

This test shall be performed in accordance with Method 1 of Test Ta of IEC 68-2-20. A screen of thermally insulating material shall be used to prevent the component being heated by direct radiation from the solder bath. It shall also allow the immersion of the terminations up to a point 2 mm away from the emergence of the terminations from the body, unless otherwise specified in the detail specification. The terminations shall be examined for good tinning, as evidenced by free flowing of the solder with wetting of the terminations.

2) *Resistance to soldering heat*

This test shall be performed in accordance with Method 1A of Test Tb of IEC 68-2-20. The immersion time shall be 5 s ± 1 s, unless otherwise specified in the detail specification. A screen of thermally insulating material shall be used to prevent the component being heated by direct radiation from the solder bath. It shall also allow the immersion of the terminations up to a point 2 mm away from the emergence of the terminations from the body, unless otherwise specified in the detail specification.

4.8.4 *Rapid change of temperature, two-fluid bath method (non destructive)*

The test shall be performed in accordance with Test Nc of IEC 68-2-14. The units shall be subjected to one cycle in a downward direction from 98 °C ± 3 °C for 15 s to 1 °C ± 1 °C for 5 s.

4.8.5 *Rapid change of temperature with prescribed time of transition (non destructive)*

The test shall be performed in accordance with Test Na of IEC 68-2-14.

For non-temperature-controlled crystal units, the low and high test chamber temperatures shall be the extreme temperatures of the operating range stated in the detail specification. For temperature-controlled crystal units, the low and high temperatures shall be –40 °C ± 3 °C and +100 °C ± 3 °C respectively.

The crystal units shall be maintained at each extreme of temperature for 15 min, unless otherwise specified in the detail specification.

The crystal units shall be subjected to ten complete thermal cycles and then exposed to standard atmospheric conditions for recovery for not less than 2 h.

4.8.6 *Bump (destructive)*

The test shall be performed in accordance with Test Eb of IEC 68-2-29. The crystal units shall be suitably mounted with clamps on the body. The three mutually perpendicular axes in which the bump is to be applied shall include:

- an axis parallel with the terminations;
- an axis perpendicular to the mounting structure at the crystal element.

The degree of severity shall be as specified in 2.3.8, unless otherwise stated in the detail specification.

4.8.7 *Vibration (destructive)*

1) *Vibration (sinusoidal)*

The test shall be performed in accordance with Test Fc of IEC 68-2-6. The crystal units shall be suitably mounted with clamps on the body. The three mutually perpendicular axes in which the acceleration is to be applied shall include:

- an axis parallel with the terminations;
- an axis perpendicular to the mounting structure at the crystal element.

The degree of severity shall be as specified in the detail specification.

2) *Random vibration*

Under consideration.

4.8.8 *Shock (destructive)*

The test shall be performed in accordance with Test Ea of IEC 68-2-27. The crystal units shall be suitably mounted with clamps on the body. The three mutually perpendicular axes in which the shock is to be applied shall include:

- an axis parallel with the terminations;
- an axis perpendicular to the mounting structure at the crystal element.

The degree of severity shall be as specified in 2.3.10, unless otherwise stated in the detail specification.

4.8.9 *Free fall (destructive)*

The test shall be performed in accordance with Procedure 1 of Test Ed of IEC 68-2-32. The crystal unit shall be suspended by its terminations at a height of 1 000 mm and the number of falls shall be two, unless otherwise specified in the detail specification.

4.8.10 *Acceleration, steady state (non destructive)*

The test shall be performed in accordance with Test Ga of IEC 68-2-7. The crystal units shall be suitably mounted with clamps on the body. The procedure and severity shall be as stated in the detail specification.

This test may be considered destructive at certain severities.

4.8.11 *Dry heat (non destructive)*

The test shall be performed in accordance with Test Ba of IEC 68-2-2. The conditioning shall be carried out at the upper temperature indicated by the climatic category for a duration of 16 h.

4.8.12 *Damp heat, cyclic (destructive)*

This test shall be performed in accordance with Test Db variant 1 of IEC 68-2-30, at severity b), 55 °C for six cycles.

4.8.13 *Cold (non destructive)*

This test shall be performed in accordance with Test Aa of IEC 68-2-1 at the lower temperature indicated by the climatic category for a duration of 2 h.

4.8.14 *Climatic sequence (destructive)*

The tests and measurements shall be performed in the following order:

– dry heat	see 4.8.11
– damp heat cyclic	see 4.8.12 (first cycle only)
– cold	see 4.8.13
– damp heat cyclic	see 4.8.12 (remaining five cycles).

In the climatic sequence, an interval of not more than three days is permitted between any of these tests, except between damp heat cyclic (first cycle) and dry cold.

In such a case, the cold test shall follow immediately after the recovery period specified for the damp heat test.

4.8.15 *Damp heat, steady state (destructive)*

This test shall be performed in accordance with Test Ca of IEC 68-2-3 for 56 days, unless otherwise stated in the detail specification.

4.8.16 *Immersion in cleaning solvents (non destructive)*

This test is applicable to superficial marking only.

To establish the permanence of marking this test shall be performed in accordance with test method 1 of test XA of IEC 68-2-45. The detail specification shall prescribe the solvent to be used.

The marking shall be legible.

4.9 *Endurance test procedure*

4.9.1 *Ageing (non destructive)*

Crystal units shall be maintained non-oscillating at 85 °C ± 2 °C for a continuous period of 30 days. The frequency and resonance resistance shall be measured at intervals of not longer than one week. The initial measurement of frequency and resonance resistance shall be taken at the end of the first 24 h and the final measurement at the end of the 30-day test.

The difference between the initial ageing measurement temperature and subsequent measurement temperatures shall not exceed ±0,5 °C. The drive level shall be as specified in the detail specification. Measurements shall be carried out according to 4.7.1 except that the measurements shall be made at 85 °C ± 2 °C.

The difference between the highest and lowest frequency measurements shall not exceed the specified value.

The resonance resistance shall not be greater than the value stated in the detail specification.

The frequency resetability accuracy of the measurement system shall be $\pm 5 \times 10^{-7}$ or ±10 % of the allowed ageing, whichever is the smaller.

4.9.2 *Extended ageing (non destructive)*

This test shall be carried out in accordance with 4.9.1 except that the continuous periods shall be 1 000 h, 2 000 h or 8 000 h, as prescribed in the detail specification and shall be used for information purposes only.

Measurements shall be carried out according to 4.7.1 except that they shall be made at 25 °C ± 2 °C or any other specified reference temperature.

NOTE - These tests are conducted for information only. The units used for these tests should not be supplied to any customer.

(Continued from second cover)

The concerned technical committee has reviewed the provisions of IEC 27; IEC 68-1(1988); IEC 68-2-1 (1990); IEC 68-2-2 (1974); IEC 68-2-3 (1969); IEC 68-2-6 (1982); IEC 68-2-7 (1983); IEC 68-2-14 (1984); IEC 68-2-17 (1978); IEC 68-2-20 (1979); IEC 68-2-21 (1983); IEC 68-2-27 (1987); IEC 68-2-29 (1987); IEC 68-2-30 (1980); Amendment 2 : 1990 of IEC 68-2-32 (1975); IEC 68-2-45 (1980); IEC 122-1(1976); Amendment 2:1991, Amendment 3: 1992, and Amendment 4: 1993 of IEC 123-3:1977; IEC 302 (1969); IEC 444-1(1984); IEC 444-2 (1980); IEC 444-3(1986); IEC 444-4 (1988); IEC 1178-3 (1993); IEC QC 001005 (1992); IEC Guide 102 (1989), referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard.

This standard is intended primarily for use under the IECQ system. A regular Indian Standard for this component could be different, identical or similar to this standard.

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.